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NARRATIVE LITERATURE REVIEW

Protective lenses in sports: a literature review

Lentes de proteção nos esportes: revisão

Ingrid de Oliveira Haubert Magalhães[1], Renata Cavalcante Girão[2], Francisco Saulo Sampaio Cardoso Tavares[2], Keila Miriam Monteiro de Carvalho[3]

1. Setor de Visão Subnormal, Departamento de Oftalmologia, Universidade Estadual de Campinas, Campinas, SP, Brazil.
2. Setor de Estrabismo e Oftalmopediatria, Departamento de Oftalmologia, Universidade Estadual de Campinas, Campinas, SP, Brazil.
3. Departamento de Oftalmologia, Hospital das Clínicas, Faculdade de Ciências Médicas, Universidade Estadual de Campinas, Campinas, SP, Brazil.

KEYWORDS:

Protective eyewear; Protective lenses; eye trauma, Sports; Eye injury; Low vision; Blindness.

SUMMARY

Objective: To perform a literature review on the use of protective eyewear in sports and its correlation with sports-related eye injuries. **Methods:** We searched the PUBMED database using keywords, such as protective eyewear, protective lenses, sports, injury in athletes, eye trauma, and special glasses. Following this, we performed a literature review of eye injuries in sports using the selected articles, with a focus on the use of protective eyewear. **Results:** We found 54 articles on the use of protective eyewear in sports up to 2018. They included a variety of sports and most of the injuries were blunt trauma caused by an object (usually a ball), of varying sizes, or direct trauma to the eye caused by a body part and/or a racquet. This report compiles data regarding these injuries to present an analysis of the topic in literature. **Conclusion:** Sports-related eye injuries account for a large proportion of the care provided by ophthalmologists, thus having a potential impact on healthcare. Herein, we reiterate the importance of raising awareness among health professionals, such as ophthalmologists and pediatricians, as well as educators, about the use of eye protection in sports. This is primarily essential for ensuring the correct prescription of eyewear and for raising awareness among patients and guardians about the importance of its use.

PALAVRAS-CHAVE:

Óculos de proteção; Lentes de proteção; Trauma ocular; Esportes; lesão ocular; Baixa visão; Cegueira.

RESUMO

Objetivo: Realizar uma revisão na literatura sobre o uso de óculos de proteção nos esportes e correlacionar com os traumas oculares oriundos da prática esportiva. **Métodos:** Pesquisa na base de dados PUBMED com as palavras-chave: óculos de proteção, lentes de proteção, esportes, traumatismos em atletas, trauma ocular e óculos especiais. Dos artigos encontrados, foi realizada uma revisão de trauma ocular nos esportes, com relação ao uso e não uso de óculos de proteção. **Resultados:** Foram encontrados 54 artigos sobre lentes de proteção ocular nos esportes até o ano de 2018. Os esportes foram diversificados, sendo que a maioria dos traumas foram contusos, através de um objeto (geralmente bola), de variados tamanhos, ou trauma direto ao olho com partes do corpo e/ou raquetes. Este artigo apresenta através de uma compilação desses dados uma análise do tema na literatura. **Conclusão:** As lesões esportivas oculares são responsáveis por uma grande proporção de atendimentos oftalmológicos, com potencial impacto na prestação de serviços. Reitera-se a importância da conscientização de profissionais de saúde como oftalmologistas e pediatras, assim como de educadores sobre o uso da proteção ocular na prática de esportes, para que se faça uma prescrição correta e alerte ao paciente e responsáveis sobre a importância do uso.

Corresponding author: Ingrid de Oliveira Haubert Magalhães. E-mail: ingridhaubert@gmail.com
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INTRODUCTION

Sports injuries account for more than 100,000 avoidable eye injuries every year. Protective eyewear (such as special glasses and helmets), reduce the risk of eye injury by about 90% as long as they fit correctly[1,2].

To determine the degree of eye protection that is required for a specific sport or activity, one should consider whether there is a risk of small particles, projectiles, or objects reaching the eyes, or a risk of substances damaging the eye surface through contact or dispersion of environmental pollutants[3].

It is recommended that every person should constantly be alert toward the possibility of potential accidents, especially around children and adolescents as they are a high-risk group for eye injuries in sports[4].

The American Academy of Pediatrics and the American Academy of Ophthalmology consider the use of protective eyewear mandatory for all functionally monocular individuals and athletes who have undergone eye surgery or have eye diseases requiring special protection, such as high myopia[5].

Alarming signs and symptoms warranting referral to the ophthalmologist

Considering the various mechanisms of trauma, the possibility of increased severity, and the importance of early treatment, some alarming signs and symptoms should be recognized as soon as possible (Table 1). If they are present, the patient should be referred to the ophthalmic emergency service[6,7]. This information should be disseminated beyond just medical professionals and is extremely important for education professionals (especially physical education teachers and coaches).

METHODS

This review sought to correlate the use of protective eyewear in sports and sports-related eye injuries, as well as evaluate the specific types of lenses used in each sport and the classification of sports-related risk. The references were obtained from the PUBMED database. The Portuguese and English keywords used included protective eyewear, protective lenses, sports, injury in athletes, eye trauma, and special glasses. The search yielded 54 articles on the topic. The patients differed in age, sex, and ethnicity. The inclusion criteria for the review were articles correlating physical activity, eye injury, and the use of protective eyewear in sports. We excluded case reports of trauma that were not sports related, studies that did not address the use of eyewear or protectors in sports, and studies that solely investigated the players' acceptance of the use of protective eyewear.

RESULTS

The search yielded 54 articles. Case reports of trauma that were not sports related, studies that did not address the use of eyewear or protectors in sports, and studies that solely investigated the players' acceptance of the use of protective eyewear were excluded from the review.

Several studies have shown a change in the scenario of this condition. Injuries are occurring more frequently in recreational and sports activities and are 2-3 times more likely to occur in outdoor environments[12,13]. The use of protective eyewear with sturdy plastic material and a safe design has been advocated[14-16].

The use of eyewear was deemed as a direct cause of eye injury in only a few articles, which did not mention the material of the lenses. The vast majority of studies strongly advocate wearing protective eyewear during sports practice to prevent eye injuries.

In a study conducted by Pieper, patients were encouraged to try wearing protective eyewear that met the safety requirements established for each sport until they found eyewear that was comfortable and

Table 1. Signs and symptoms that require referral to an ophthalmological emergency service

1. Sudden loss or decreased vision
2. Loss of visual field
3. Pain on eye movement
4. Photophobia
5. Proptosis
6. Flashes of light or floaters
7. Diplopia
8. Pupil shape irregularity
9. Foreign body sensation/presence of foreign body
10. Red or inflamed eye
11. Blood inside the anterior chamber (hyphema)
12. Halos around the light (corneal edema)
13. Laceration of the eyelid margin or near the medial corner
14. Subconjunctival hemorrhage
15. Folded or corrugated contact lenses/broken glasses
16. Suspected eyeball perforation

References[8-11]

fit perfectly. In addition, patients were informed that the sensation of impaired vision caused by the bars on the protective eyewear worn in some sports would probably disappear with time[17].

Ong et al. conducted a study in an ophthalmological hospital in the city of London between May and July 2008 to investigate the role of protective eyewear in the prevention of sports-related eye injuries. Despite the short study period (3 months), 48 patients with sports-related eye injuries were identified. Of these, 14 (29.2%) had 1 eye lesion, 18 (37.5%) suffered 2 eye lesions, and 10 (20.8%) had >2 eye lesions. Sixteen patients (33.3%) suffered trauma to the anterior and posterior segments. One patient (2%) was wearing prescription glasses (the material of the lenses was not mentioned), whose lenses shattered when hit by a shuttlecock, resulting in a penetrating injury. All patients (100%) were injured in only 1 eye. No patient wore eye protection or received advice on the prevention of future injuries, according to records[18].

Moon et al. conducted a study correlating eye injuries and sports and concluded that lesions were more common in patients aged <10 years and that the rate of protective eyewear use was lower among these patients. This rate was also low among adults and their injuries commonly occurred during walking. The authors suggest that athletes should be educated and supplied with protective eyewear, and that a policy for the use of protective equipment should be implemented[19].

Parver et al. conducted a study from 1985 to 1991 in which they observed that glass or plastic were reported as the cause of trauma in 2.9% of cases of eye injuries occurring in individuals who wore eyewear, which suggests that the broken lens contributed to the lesion[14].

Christianson et al. conducted a retrospective study from 1967 to 1977 and detected 446 penetrating eye injuries. They attributed 16 of them to the use of eyewear (unspecified material)[16].

In a study conducted in 2015 by Kriz et al., it was confirmed that a national mandate for protective eyewear to be worn by girls participating in field hockey in the US was associated with a 3-fold reduction in the rate of ocular/orbital injuries, without significantly increasing the frequency of player-to-player head or face contact and lesions, including concussion[20].

Bro and Ghosh conducted a study in Sweden and reported that only 1 of 98 patients with eye injury caused during floorball had worn protective eyewear at the time of injury. Sixty-eight percent of players registered in the Swedish Floorball Federation stated that protective eyewear is required for players <15 years of age. Injuries among registered players are unusual, which indicates that this requirement is effective in eye protection[21]. In another study conducted in Finland by Leivo, Puusaari, and Mäkitie (2007), only a small percentage of floorball players wore protective eyewear[22]. In 2015, compared to the previous study, Leivo, Haavisto, and Sahraravand showed that eye injuries in floorball decreased significantly, mainly due to mandatory use of protective eyewear for younger players, and recommended that it becomes mandatory for all ages[23].

Micieli, Zurakowski, and Ahmed, in a study published in 2014, showed that the individual risk of eye or orbital injury is significantly increased in players who choose not to use a visor in hockey[24].

In a retrospective study conducted in Austria by Weitgasser, Wackernagel, and Oetsch on patients with golf-related eye injuries and who had been hospitalized for ophthalmic treatment between 1993 and 2000, 3 individuals had closed-eye injury and 4 had eyeball rupture. All patients required surgery, with the resulting visual acuity ranging from hand motion to 20/20. Three eyes required enucleation. Given the serious complications resulting from golf-related eye injuries, the authors believe that eye protection should be considered and promoted[25]. The authors Goldstein and Wee[26] and Napier et al.[27] recommended not wearing regular glasses during sports activities due to their propensity to shatter and cause additional injuries, especially during sports involving projectiles. In a study conducted by Crane et al., it was observed that the rate of eye injuries in golf was significantly lower among individuals who did not wear glasses than among those who wore glasses or sunglasses. This may be due to sunglasses and glasses protecting against minor injuries and the golfer not seeking subsequent care, or it may be more likely due to eye damage caused by sunglasses or glasses. It is recommended that golfers who wear sunglasses consider using glasses that conform to the American Society for Testing and Materials (ASTM) F803 standard[28]. With regard to cricket, authors Mann and Dain suggest considering a change in regulations to encourage the use of appropriate safety measures and personal eye protection by wicket-keepers[29,30]. Paintball is another sport associated with significant risk of severe eye injuries[31,32]. Standard practice procedures for paintball have been established by the ASTM,

which specify minimum safety requirements, such as eye, ear, and face protection. Most of the reported injuries occurred while the athletes were not wearing protectors. Fogging up of lenses was 1 of the reasons why players removed them[31].

With regard to squash, there are publications since 1978 advocating that healthcare professionals should be responsible for encouraging players to play squash with adequate eye protection[33].

Lacrosse is another sport that is commonly associated with eye injury. Injuries occur at all levels of the game, in many different situations, and by various mechanisms. Therefore, mandatory use of eyewear is necessary to avoid serious eye injuries, especially in women's lacrosse[34].

DISCUSSION

Mechanisms of injury in sport

There are several mechanisms of eye injury, such as open-eye injury and closed-eye injury[35], the most common in sports being closed-eye injury[36].

The severity of the trauma will depend on the speed, force, and size of the object when it hits the eye. Objects smaller than the eyeball (<5cm) tend to compress the anterior segment of the eye, which distends medially, and increase the pressure on the intraocular structures, whereas objects larger than the eyeball (>5cm) increase the pressure on the floor or medial side of the eyeball, causing bone injury[37].

Traumatic optic neuropathy is a condition that may occur either by direct injury to the optic nerve fibers (by bone fragments, hematomas, or penetrating injury) or by indirect injury, that is, damage due to transmission of forces to the optic canal. It is common for funduscopy to appear normal in the acute phase and progress with optic atrophy 3-6 weeks after the injury[36].

Risk classification in sports

Sports can be classified according to their risk of causing eye injury, whether by collision, contact, or non-contact. They are classified into low-risk, moderate-risk or high-risk sports. In addition, some sports are considered safe for the eyes[29,36] (Table 2).

Protective eyewear recommended for sports

The recommended eye protection for each sport is guided by the principle of energy absorption in a protective device that sits in front of the eyes (racket sports, baseball, and basketball). It should be determined by standards established by the ASTM[5]. Protective eyewear or glasses with UV protection should be worn during snow or water skiing. They help protect the eyes from sunburn and glare. Protective eyewear is often made of polycarbonate, a highly impact-resistant plastic capable of absorbing UV light. This plastic is 8 times stronger than other materials and is therefore preferred for use in protective eyewear. The impact resistance of normal glasses is only 4% to 5% that of polycarbonate of comparable thickness[37].

Rimless glasses and smaller frames increase the risk of eye injuries[38].

Below is the recommended protective eyewear for each sport (Table 3)[39].

Impact and energy of the object

In addition to the choice of lens material, the structure and fit of the eyewear influence protection[38]. Most work-related eye injuries, despite the use of protective eyewear, are caused by objects coming from above, below, or the side of the protective eyewear[39].

Examples of the impact and average energy of objects used in some sports in various countries across the world are shown below (Table 4).

Resistance of optical materials

Plastics are generally more resistant to impact than glass, especially to small, fast-moving objects. Polycarbonate is universally reported as the most impact-resistant eyewear lens material[37].

There are several materials that can be used for eyewear frame manufacture, including polycarbonate and thermoplastic, which can incorporate foam coatings. These provide comfort and cushioning against any impact transferred to the eyeball[27].

Patients with monocular vision and athletes with subnormal vision

Protective eyewear is mandatory for patients with low vision or monocular vision, as well as those who underwent ophthalmic or post-traumatic surgery[40]. Patients with subnormal vision, history of eye injury, monocular vision, or pre-existing eye disease (such as high myopia or retinal degeneration) should consult an ophthalmologist[41] for assessment and guidance on the risks to vision arising from specific sports and long-term consequences that may affect the injury in the good eye[42].

Table 2. Sports risk classification for a patient without eye protection[36]

High-risk	Moderate-risk	Low-risk	Eye Safe
Quick, small projectiles	Badminton	Swimming	Track and Field
Air rifle, Paintball	Tennis	Diving	Gym
Heavy projectiles, sticks	Volleyball	Ski (snow and water)	
Closed contact,	Water Polo	Wrestling	
Squash	Football	Cycling	
Cricket	Fishing		
Baseball	Golf		
Lacrosse			
Hockey			
Racquetball			
Intentional injury			
Boxing			
Martial Arts – Direct contact			

Table 3. Type of goggles for each sport

Sport	Minimal eye protector	Comment
Baseball/softball (youth batter and base runner)	ASTM F910	Face guard attached to helmet
Baseball/softball (fielder)	ASTM F803 for baseball	ASTM specifies age ranges
Basketball	ASTM F803 for basketball	ASTM specifies age ranges
Bicycling	Helmet plus streetwear/fashion eyewear	
Boxing	No available; not permitted in sport	Contraindicated for functionally one-eyed athletes
Fencing	Protector with neck bib	
Fieldhockey (men and women)	ASTM F803 for women's lacrosse Goalie full face mask	Protectors that pass for women's lacrosse also pass for field hockey
Football	Polycarbonate eye shield attached to helmet-mounted wire face mask	
Full-contact martial arts	No available; not permitted in sport	Contraindicated for functionally one-eyed athletes
Racquet sports (badminton, tennis, paddle tennis, handball, squash and racquetball)	ASTM F803 for selected sports	
Soccer	ASTM F803 for selected sports	
Street hockey	ASTM 513 face mask on helmet	Must be HECC or CSA certified
Track and Field	Streetwear with polycarbonate lenses/ fashion eyewear*	
Water polo/ swimming	Swim goggles with polycarbonate lenses	
Wrestling	No standard available	Optional custom protective eyewear

*Eyewear that passes ASTM F803 is safer than streetwear eyewear for all sports activities with impact potential[39].

Table 4. Impact energy for some sports27[27]

Calculation of kinetic energy	Speed	Mass	Impact energy
Golf Ball	145km/h	45.8	37.1
Tennis ball	177km/h	58.9	68.3
Lacrosse Ball	113 km/h	150.4	69.0
Baseball ball	152 km/h	142	125

Table 5. Recommendations to athletes regarding the use of goggles

1. Young people involved in organized sports should be instructed to wear appropriate eye protection.
2. Goggles recommended for each sport, as mentioned in Table 3, must be prescribed. Adequate adjustment must be made. Some children have narrow facial features and may be unable to wear even the smallest sports glasses. These children can be equipped with 3 mm polycarbonate lenses in the ANSI Z87.1 standard, designed for children. Parents should be informed that this protection is not ideal, and the choice of sports that are safe for the eyes should be discussed.
3. It is recommended that athletes who wear contact lenses also wear the appropriate eye protection listed in Table 3, as contact lenses do not provide protection.
4. An athlete who needs prescription glasses has 3 eye protection options: a) polycarbonate lenses in a sports structure that follows the ASTM F803 standard for the specific sport; b) contact lenses plus an appropriate protector; or c) an over-the-glasses eye protector that conforms to the specifications of the ASTM F803 standard for sports where an ASTM F803 standard protector is sufficient.
5. All athletes with functional single eye must wear eye protection suitable for all sports.
6. Athletes with a functional single eye and those who have had an eye injury or surgery should not participate in boxing or contact martial arts. (Eye protection is not allowed in these sports). Wrestling has a low incidence of eye damage. Although there are no standards, the eye protectors that are firmly attached to the head have been customized. The fighter who has a custom-made eye protector should be aware that the design of the protector may be insufficient to prevent injury.
7. For sports in which a face mask or helmet with eye protection or shield must be worn, it is highly recommended that athletes with a functional eye also wear sports goggles that comply with the requirements of the ASTM F803 standard. This is to maintain some level of protection if the face shield is raised or removed, such as for hockey or football players on the bench. The helmet must fit properly and have a chin strap for optimal protection.
8. Athletes should replace sports eye protectors that are damaged or yellowed by the wear and tear of time, because they may have weakened and therefore are no longer protective.

Source: American Academy of Pediatrics American Academy of Pediatrics. Committee on Sports Medicine and Fitness; American Academy of Ophthalmology, Eye Health and Public Information Task Force. Protective eyewear for young athletes. Ophthalmology. 2004[36].

Eye protection in sports among children and young adults

According to the American Academy of Pediatrics and the American Academy of Ophthalmology, it is highly recommended to use eye protection in sports that pose a risk of eye injury. The recommendations to be provided to athletes are shown in Table 5[40].

Sports-related eye injuries account for a large proportion of emergency eye care, with potential impact on care provision.

The recommended protective eyewear required for each sport is guided by the principle of energy absorption in a protective device that is placed in front of the eyes in sports that use a racket, bat, or ball, such as tennis, baseball, and basketball, respectively.

Considering the importance of preventing eye injury in sports, health professionals and educators should be made aware of the correct use of protective lenses in sports.

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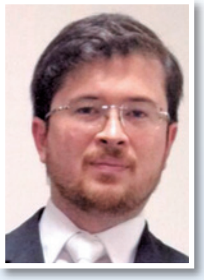
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AUTHOR'S INFORMATION



» **Ingrid O. H. Magalhães**
http://lattes.cnpq.br/8156941436811256
https://orcid.org/0000-0001-9723-1961



» **Francisco S. S. C. Tavares**
http://lattes.cnpq.br/1774291250318839
https://orcid.org/0000-0002-2799-0636



» **Renata C. Girão**
http://lattes.cnpq.br/9176734716498992
https://orcid.org/0000-0002-3853-9429



» **Keila M. Carvalho**
http://lattes.cnpq.br/0606513121982929
https://orcid.org/0000-0002-7976-8017